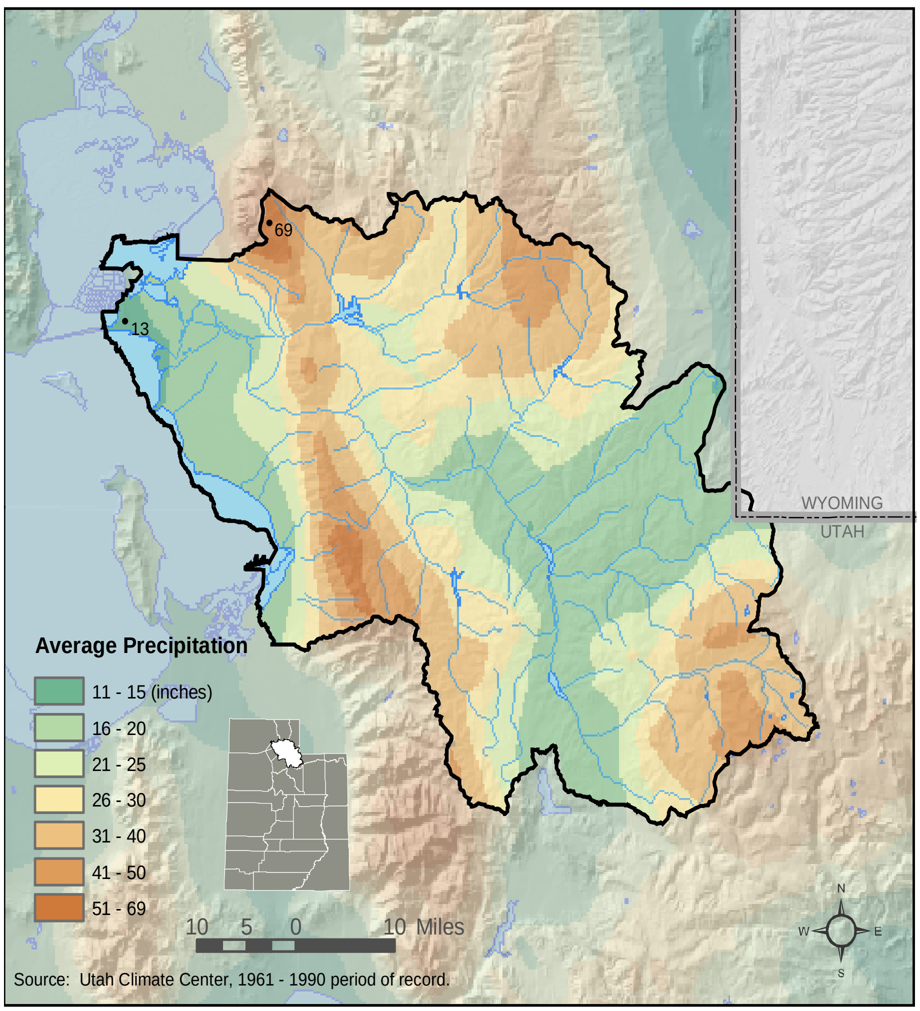
2

WATER SUPPLY

The Weber River Basin receives an average of 27 inches of precipitation annually. This precipitation is distributed as shown in Figure 2 and ranges from a low of about 13 inches near Ogden Bay to a high of over 60 inches on Ben Lomond Peak. The average amount of precipitation that the Weber River Basin receives is more than any of Utah's other major river basins. The Weber River Basin experiences higher than normal precipitation mainly because 80 plus percent of its land area is composed of mountain ranges and mountain valleys that are at an elevation of 5,000 feet or more. The basin is also fortunate in that its land area receives a substantial amount of precipitation due to the winter lake

FIGURE 2
Average Annual Precipitation



effect caused by the Great Salt Lake. As a result, the Weber River Basin has the second highest ratio of water yield to land area (0.70) of any basin within the state (see Table 1).

TABLE 1
Ratio of Water Yield to Land Area for Major Basins in Utah

Basin	Average Water Yield* (acre-feet/yr.)	Land Area† (acres)	Ratio (acre-feet/acre)
Bear River	1,822,000	2,149,000	0.85
Weber River	1,091,000	1,561,000	0.70
Jordan River	296,000	497,000	0.60
Utah Lake	857,000	1,945,000	0.44
Uintah	1,472,000	6,970,000	0.21
Sevier River	823,000	6,768,000	0.12
Kanab Creek/Virgin River	235,000	2,237,000	0.11
West Colorado River	585,000	9,863,000	0.06
Cedar/Beaver	179,000	3,616,000	0.05
West Desert	400,000	11,737,000	0.03
Southeast Colorado River	131,000	6,961,000	0.02
STATEWIDE TOTAL	**7,891,000**	**54,304,000**	**0.14**

* Source: Utah Division of Water Resources, The Utah Water Data Book, (Salt Lake City: Dept. of Natural Resources, 1997), 2.
† These figures do not include basin land area that is not in Utah.

CLIMATE

The climate of the Weber River Basin is typical of the semiarid central and northern mountainous regions of Utah. Table 2 contains climatological data for many of the weather stations within the basin. Average annual temperatures at the various stations range from a low of 43.7° F at Pine View Dam and Kamas to a high of 51.5° F in Ogden, a variance of about 15 percent. The record high and low temperatures are 106° F (July-Ogden Sugar Factory) and -39° F (February-Pine View Dam), respectively. Average annual precipitation varies more than 50 percent from a low of 13.06 inches at Bear River Bay near Plain City to a high of 30.85 inches at Pine View Dam. Evapotranspiration (see Evaporation and Transpiration discussion below) varies by about 25 percent, with a low of 39.06 inches at Bear River Bay and a high of 50.95 inches at the Huntsville Monastery.

Figure 3 contains a temperature chart and a precipitation/evapotranspiration chart for four of the weather stations listed in Table 2. As shown in the precipitation/evapotranspiration charts on the right, evapotranspiration (red line) exceeds normal precipitation (dark blue column) during all but the winter months. This is why the basin's climate is considered semiarid and articulates clearly why it is necessary to irrigate crops and landscapes in Utah. Even more interesting is the fact that evapotranspiration even exceeds

TABLE 2
Climatological Data (1948-1992)*

Station	Temperature (Average Max and Min)							Precipitation		ET†	
	January		July			Record					
	Max (ºF)	Min (ºF)	Max (ºF)	Min (ºF)	Avg. Ann.	Max (ºF)	Min (ºF)	Snow (in.)	Avg. Ann. (in.)	Avg. Ann. (in.)	Frost Free Days§
Davis County											
Bountiful-Val Verda*	34.6	19.7	88.2	63.9	51.4	101	-9	59.2	23.24	41.30	192
Farmington USU Field Station	37.3	19.8	91.7	60.2	51.2	102	-14	52.1	22.73	46.73	162
Weber County											
Bear River Bay*	32.3	18.7	88.9	66.4	51.3	105	-9	10.4	13.06	39.06	194
Huntsville Monastery*	33.2	8.3	87.4	41.2	44.7	98	-37	56.7	21.44	50.95	87
Ogden Pioneer Powerhouse‡	36.4	19.0	91.0	62.8	51.5	105	-23	37.0	22.62	45.15	165
Ogden Sugar Factory	35.9	17.3	92.1	59.8	50.7	106	-26	25.0	16.84	46.42	161
Pine View Dam‡	30.4	6.9	86.6	50.3	43.7	100	-39	118.4	30.85	43.24	124
Riverdale	36.0	18.1	90.5	59.8	50.3	104	-25	29.0	19.94	45.03	154
Morgan County											
Morgan	34.7	10.6	88.9	49.9	45.8	101	-33	72.0	19.72	47.08	102
Summit County											
Coalville	36.8	10.7	85.9	46.5	44.8	99	-33	73.0	16.42	46.39	79
Echo Dam	34.4	10.2	88.1	49.3	44.9	100	-34	67.4	14.94	45.56	95
Kamas 3 NW‡	35.3	10.5	84.5	66.5	43.7	100	-31	86.7	18.00	42.86	83
Park City Radio‡	35.0	15.2	81.7	51.8	44.0	93	-30	139.7	20.68	40.00	97
Wanship Dam*	35.1	10.6	85.5	46.9	43.9	98	-37	63.8	16.61	44.51	73

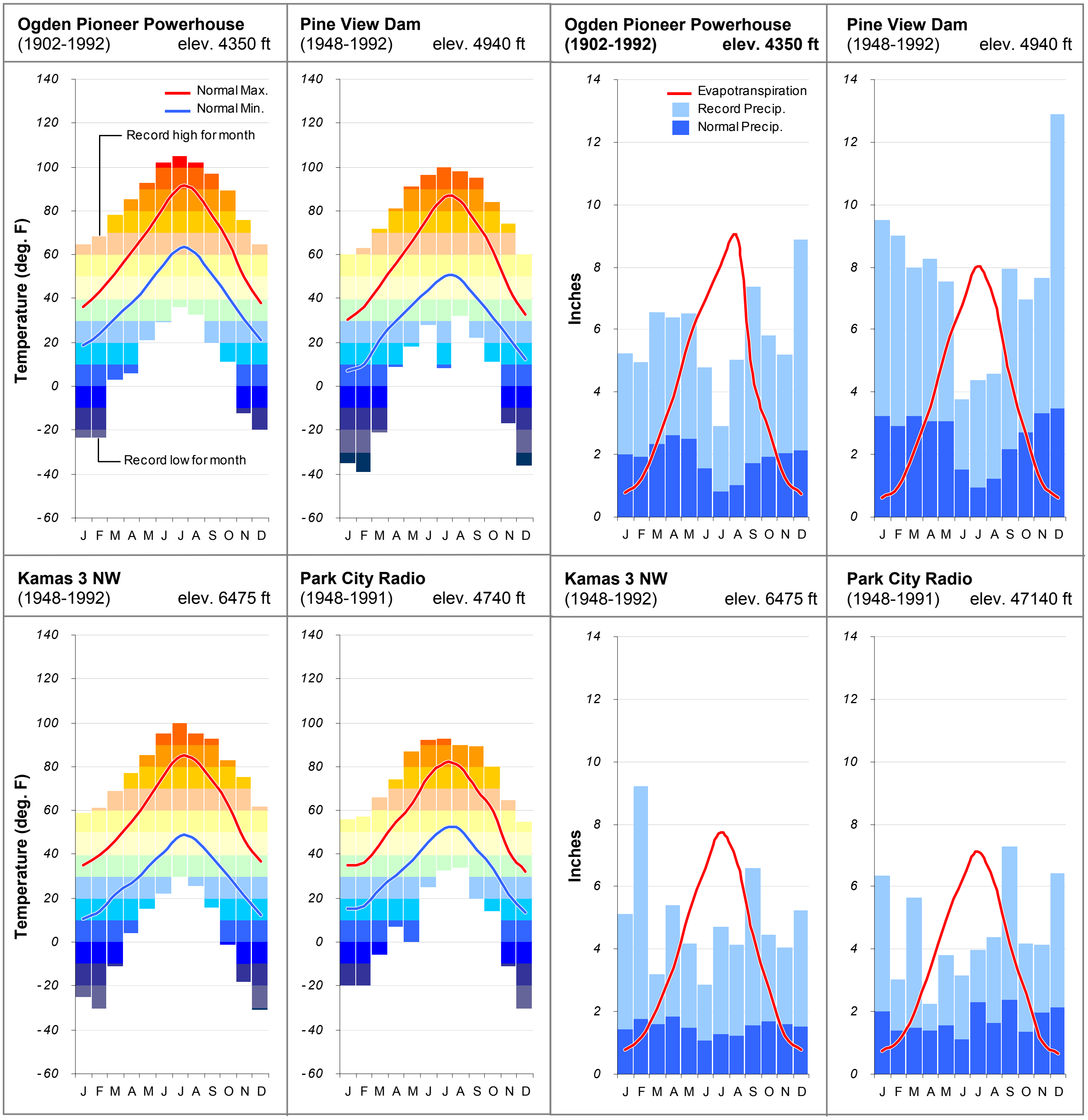
Source: Utah Climate Center, Utah Climate, (Logan: Utah State University, 1996).
* Period of record is 1948-1992 or longer except for the following stations: Bountiful-Val Verda (1981-1992), Bear River Bay (1969-1992), Huntsville Monastery (1976-1992), Wanship Dam (1955-1992).
† Reference Evapotranspiration
‡ See Figure 3 for a visual representation of the data for this weather station.
§ Frost free days retrieved from the Utah Climate Center's Internet web page: http://climate.usu.edu/freeze/, November 25, 2003.

the record precipitation at every station during the summer months of June, July and August. Thus, even during the wettest of summer months, it is still necessary to irrigate crops and landscapes.

Precipitation

Most of the precipitation that occurs in the Weber River Basin falls on the mountains and mountain valleys as snow (see Figure 2 shown previously). This snow is extremely important to the water supply of the basin because it functions as a storage reservoir, releasing the water into streams and aquifers as temperatures rise. Depending on surface conditions of the soil and the rate of melting, the precipitation that is not evaporated or

FIGURE 3
Temperature (left), Precipitation and Evapotranspiration (right) at Four Weather Stations



Source: Gaylen L. Ashcroft, Donald T. Jensen, and Jeffrey L. Brown, *Utah Climate*, (Logan: Utah Climate Center, 1992), 53, 67, 69, 71.

used by vegetation flows directly into streams or it seeps into the soil. While much of the precipitation makes its way to surface waterways, some of it percolates into the soil and becomes part of the basin's ground water. Topography, soil characteristics, geologic configurations and other factors affect the path and movement of ground water. At some lower elevation, it may come to the surface as a natural spring or seep, discharge into a lake or river, or become part of the ground water storage in the lower valleys.

Although precipitation varies significantly from one point within the basin to another, it averages about 27 inches or 3.45 million acre-feet[1] per year. Table 3 lists the average annual precipitation values for each of the basin's major watersheds. As shown, the Upper Weber River watershed receives the highest amount of precipitation, about 36 inches per year. Ogden Valley is not far behind, receiving 33 inches. The East Shore watershed, where the majority of the basin's population resides, receives about 23 inches of precipitation per year. Surprisingly, three of the watersheds located in the upper portion of the basin all receive less precipitation than the East Shore watershed—the watershed with the lowest average elevation.

TABLE 3
Average Precipitation by Watershed

Watershed	Average Annual Precipitation (in.)
Upper Weber River	36
Ogden Valley	33
East Canyon Creek	31
Morgan	30
Lost Creek	30
East Shore	23
Kamas Valley	22
Chalk Creek	22
Echo Creek	18
WEBER BASIN AVERAGE	**27**

Source: Utah Climate Center, Utah State University. Values derived from a precipitation grid representing the 1961-1990 period of record.

Evaporation and Transpiration

Precipitation is the process that moves water from the atmosphere to the surface of the earth. Evaporation returns some of this water to the atmosphere through vaporization directly from the surface of the Earth; transpiration returns water to the atmosphere through skin and plant tissue. These two terms are often combined into one "evapotranspiration" to represent their net effect. Evapotranspiration is highly dependent upon solar radiation, temperature, humidity and wind.

Approximately 68 percent, or 2.36 million acre-feet, of the precipitation falling on the Weber River Basin each year is removed by the natural environment through evapotranspiration before it reaches a stream or aquifer where it can be used by man. An additional 7 percent, or 230,000 acre-feet per year, is removed by the environment through evaporation from lakes and reservoirs or transpiration from riparian and wetland vegetation after it reaches areas where it can be used. About 20 percent of this, or 47,000 acre-feet per year, evaporates from Willard Bay and other reservoirs in the basin.[2]

AVERAGE ANNUAL WATER SUPPLY

Surface Water

The portion of precipitation not initially evaporated or transpired by vegetation eventually makes its way into streams and other surface water-bodies, or percolates into the ground water. Surface water can be quantified at gauging stations on stream segments. The U.S. Geological Survey, in cooperation with other federal and state entities, monitors an extensive network of gauging stations throughout Utah. Table 4 shows the average annual flow for selected gauged streams and rivers in the Weber River Basin. Figure 4 shows the average annual stream flow and depletions for the entire Weber River Basin for the 1961-1990 period.

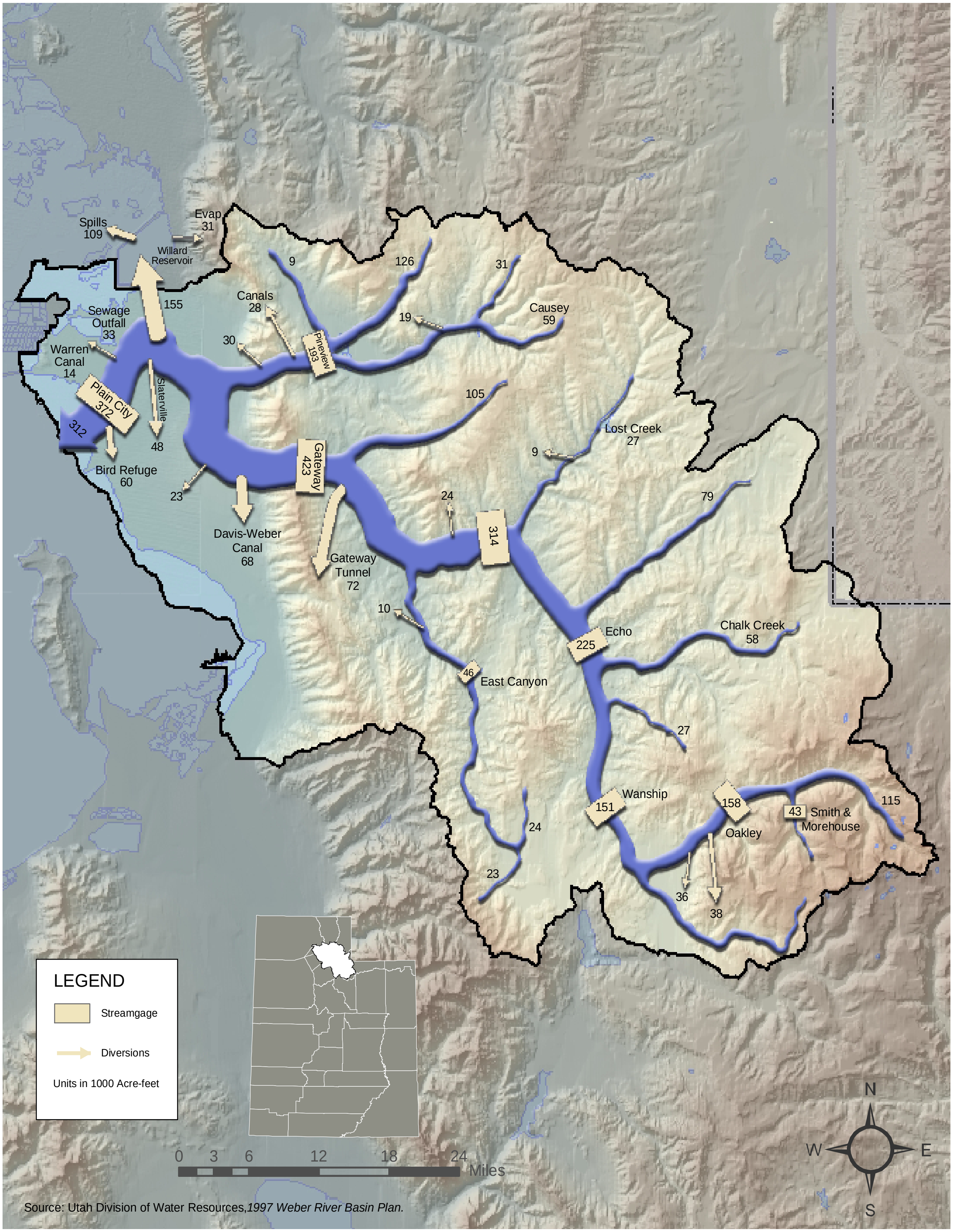
TABLE 4
Average Annual Flow at Various Gauging Stations

Stream Gage Name	Years of Record	Average Ann. Flow (acre-feet/yr.)
Smith & Morehouse Creek near Oakley	1947, 1976-87	44,689
Weber River near Oakley	1905-2002	158,509
Weber River near Coalville	1927-2002	153,348
Chalk Creek at Coalville	1928-2002	49,645
Weber River at Echo	1927-2002	205,656
Lost Creek near Croydon	*	21,473
Weber River at Devil's Slide	1905-1955	314,272
East Canyon Creek near Morgan	1932-2002	41,183
Weber Rover at Gateway	1921-2002	403,010
South Fork Ogden River near Huntsville	1922-2002	82,984
North Fork Ogden River near Eden	1964-1974	8,756
Wheeler Creek near Huntsville	1959-1995	7,260
Ogden River by Pineview Dam	1937-1959	64,165
Weber River near Plain City	1908-2002	426,680
Farmington Creek above Diversion	1950-72, 1976-79	9,111
Centerville Creek above Diversion	1950-80, 99-2002	2,141
Mill Creek at Mueller Park near Bountiful	1951-1986	4,659

* Years of record are sporadic (1921-25, 1940-68, 1976, 1989-2002).

FIGURE 4

Average Annual Stream Flow & Depletions



Source: Utah Division of Water Resources, *1997 Weber River Basin Plan.*

As apparent from Figure 4, the Ogden River is the most significant tributary to the Weber River. Other major tributaries include East Canyon, Lost, Echo, Chalk, Silver, Beaver and Smith & Morehouse creeks. Although a large portion of the basin's population lives near Ogden, where the Ogden River joins the Weber River, a significant portion of the population lives south of this point along the much smaller streams emanating from the Wasatch Range. This fact, combined with the rapid growth of the Park City area at the headwaters of East Canyon Creek, highlights one of the main challenges facing the Weber River Basin today—delivering the water supply of the basin to those areas where it is in highest demand.

Ground Water

Detailed estimates of developed ground water supply exist for the areas of the state with significant ground water use. These are the East Shore area, Ogden Valley and Park City area. Table 5 lists the estimated withdrawal of ground water in each of these areas. The withdrawal estimates are based on available data for the year shown.

TABLE 5
Estimated Ground Water Withdrawals in Selected Areas of the Weber River Basin

Area	Year	Withdrawal (acre-feet/yr.)
East Shore area	2001	57,000
Ogden Valley	2001	11,100
Park City area	1999	4,800
	TOTAL	**72,900**

Sources: U.S. Geological Survey, Ground-Water Conditions in Utah, Spring of 2002, (Salt Lake City: Utah Dept. of Natural Resources, 2002), 5, 102. Utah Division of Water Rights, Snyderville/Park City Basin Ground-Water Useage Report, obtained online at: www.waterrights.utah.gov/ wrinfo/policy/ground.htm, November 12, 2003.

East Shore Area[3]

The East Shore area is located between the Wasatch Range and Great Salt Lake and is bounded on the north by North Ogden and on the south by North Salt Lake. Ground water occurs in unconsolidated deposits under both water-table and artesian conditions. Most water is withdrawn from the deep, confined portion of the aquifer. Water enters the artesian aquifers along the east edge of the Weber River Delta and all along the Wasatch Fault zone where the aquifers are unconfined.

Figure 5 shows hydrographs of two wells in the East Shore area and the other areas with significant ground water withdrawals in the basin. While water levels have generally declined throughout the East Shore area since the 1950s, a few wells, including the one shown near Woods Cross, have experienced a slight increase in water level. Water levels around Hill Air Force Base in northern Davis County have experienced some of the largest declines in all of Utah.[4] The State Engineer has closed the East Shore area to new ground water appropriations, except for one acre-foot applications and shallow wells less than 30 feet deep.

Ogden Valley[5]

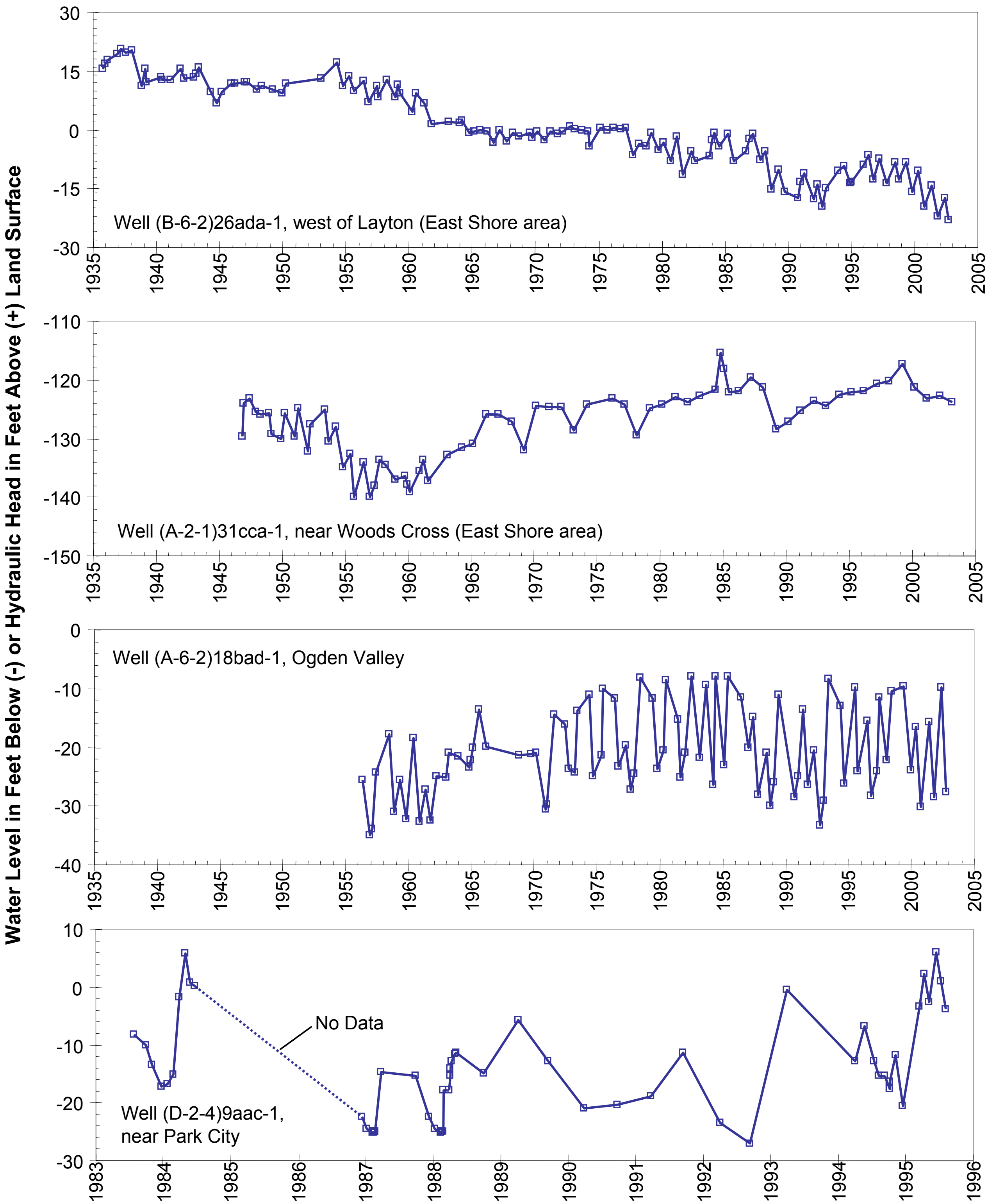
The Ogden Valley is located entirely in Weber County east of the Wasatch Range. Ground water occurs in unconsolidated deposits under both water-table and artesian conditions. Water is withdrawn primarily from the artesian aquifers which generally have recharge zones along the flanks of the valley. Figure 5 includes the hydrograph at one representative well location within Ogden Valley.

Park City Area[6]

The Park City Area is located in the southwestern corner of Summit County and includes all of the East Canyon Creek drainage within the county and most of the Silver Creek drainage. Ground water within the area is present in consolidated rocks and unconsolidated valley fill. The complex geology makes it difficult to determine the degree to which various water-bearing formations are connected.

Water levels within the area fluctuate seasonally, and generally mirror rates of precipitation, snowmelt, etc. Figure 5 includes one hydrograph from a well near Park City. Despite a steady increase in pumping from 1983 to 1995, ground water levels in this well indicate no long-term decline. However, significant water level drops have been observed in many wells since 1995 as a result of the recent drought. These declines have prompted a careful review of all water rights in the area by the State Engineer. As a result of this review, ground water withdrawals may need to be curtailed in the future to avoid overdraft of the ground water resources.

FIGURE 5
Hydrographs for Selected Wells in the East Shore Area, Ogden Valley and Park City



Source: U.S. Geological Survey, National Water Information System web page: nwis.waterdata.usgs.gov, April 2004.

Available Water Supply

TABLE 6
Estimated Water Budget

Category	Water Supply (acre-feet/yr.)*
Total Precipitation	3,453,000
Used by vegetation and natural systems	2,362,000
Basin Yield	*1,091,000*
Weber-Provo Canal Exports	(45,000)
Net Ground Water Inflows†	49,000
Available Supply	*1,095,000*
Agricultural Depletions‡	170,000
M&I Depletions‡	85,000
Other Depletions§	230,000
Flows to Great Salt Lake	*610,000*

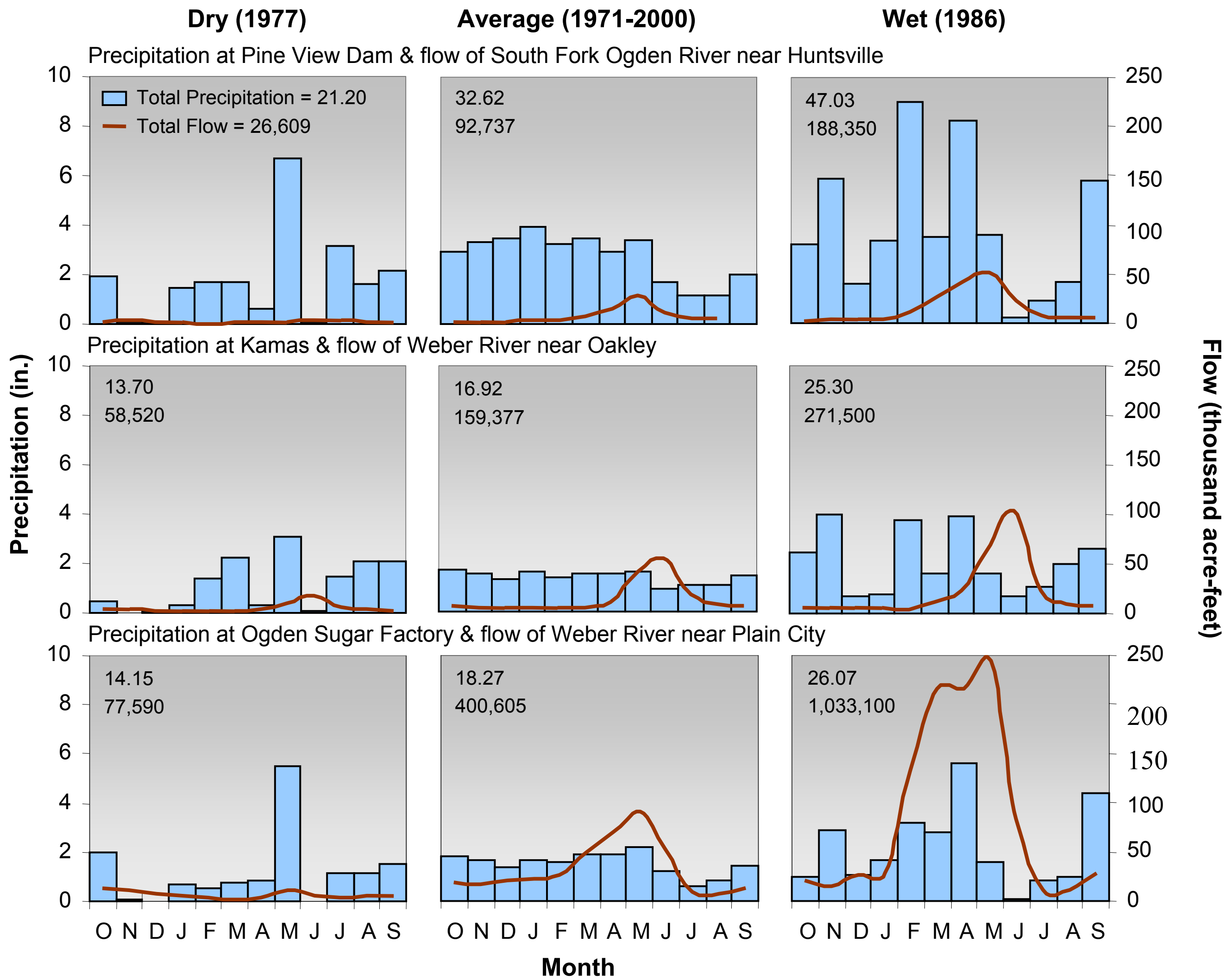
* Values based on 1961-1990 period of record, except as noted.
† Estimated inflows from north and south along the east shore of the Great Salt Lake.
‡ Based on irrigated cropland observed in 2003 and M&I data collected in 2001 by the Division of Water Resources.
§ Wetland and riparian depletion and reservoir evaporation.

The combination of all the climatological data with the streamflow and ground water data presented to this point yields a snapshot of the water supply in the Weber River Basin. This is contained in Table 6, which shows the disposition of the average annual precipitation that falls within the basin (3.453 million acre-feet).

After the initial evaporation and transpiration from vegetation and natural systems (2.362 million acre-feet), approximately 32 percent (1.091 million acre-feet) makes its way into the Weber River, its tributaries and the basin's ground water aquifers each year. This is called the "Basin Yield."

Approximately 45,000 acre-feet per year is exported out of the basin[7] and approximately 49,000 acre-feet per year of ground water enters the basin near the Great Salt Lake leaving a net available water supply of approximately 1.095 million acre-feet per year. Currently, annual agricultural depletions in the Weber River Basin amount to about 170,000 acre-feet and annual municipal and industrial (M&I) depletions amount to 85,000 acre-feet, or 16 and 8 percent of the available water supply, respectively. Reservoir evaporation and other natural depletions combine to deplete another 230,000 acre-feet per year, or 21 percent. This leaves an annual average of about 610,000 acre-feet of the available supply (or 55 percent) that enters the Great Salt Lake from the Weber River Basin.

FIGURE 6
Precipitation and Flow for a Dry, Average and Wet Year at Various Locations in the Basin



VARIABILITY OF SUPPLY

For the sake of convenience, the discussion to this point has focused on the Weber River Basin's average annual water supply. Actual water supply conditions rarely match these averages. In fact, it is not unusual to experience water supply conditions in extreme excess or deficit of the average. Figure 6 illustrates the precipitation and streamflow for a dry, average and wet year at several locations in the basin. The blue bars show monthly precipitation in inches and the red lines show monthly streamflow in acre-feet.

The extreme range of Weber River flow at the Plain City gage (77,590 acre-feet in 1977 to 1,033,100 acre-feet in 1986) exemplifies the fact that actual water supply can vary substantially from the average amounts.

This variability also emphasizes the importance of water storage reservoirs to the basin. Without the benefits of storage, the effects of prolonged drought periods would be severely felt, as would the effects of flooding during wet periods. Instead, storage reservoirs allow much of the excess flows available during wet years to be captured and held in storage for use in subsequent years.

NOTES

[1] An acre-foot is enough to cover an acre of land with one foot of water, or to satisfy the needs of a family of four or five for one year.

[2] Utah Division of Water Resources, *Water Budget Report of the Weber River Basin,* (Salt Lake City: Utah Dept. of Natural Resources, 1996),87, 89. Of this amount, 31,000 acre-feet evaporates from Willard Bay and 16,000 acre-feet from other reservoirs.

[3] U.S. Geological Survey, *Ground-water Conditions in Utah: Spring of 2002*, Cooperative Investigations Report No. 42, (Salt Lake City: U.S. Geological Survey, 2002), 18-23.

[4] The Division of Water Resources has estimated that wells in this area have declined anywhere from 50-70 feet, since 1950.

[5] U.S. Geological Survey, 2002, 111-112.

[6] U.S. Geological Survey, *Hydrology and snowmelt simulation of Snyderville Basin, Park City, and adjacent areas, Summit Couty, Utah,* (Salt Lake City: Dept. of Natural Resources, 1998), 7.

[7] This includes an export 38,000 acre-feet per year to the Utah Lake Basin through the Weber-Provo Canal and an export of 7,000 acre-feet per year to the Bear River Basin through the Ogden-Brigham Canal.